Space Weather Technical Forecast

Issued on Thursday 19 December 2024 at 13:10 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

---

Space Weather Forecast Headline: Chance of M-class flares (R1-R2; Minor-Moderate Radio Blackouts) throughout.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Moderate with a peak M1.6 flare at 19/1038 UTC, which is most likely from the largest region on the visible side (AR3924) in the southwest.. There are six other sunspot regions on the Earth-facing disc. AR3924 (Eho/Beta-Gamma) remains the most complex sunspot group on the disc, but the region has shown stability. AR3922 (Dso/Beta) has also shown little overall change in the past 24 hours and has remained stable. A third region AR3927 in the southeast is growing in size and becoming more complex. All other spots remain magnetically simple. No Earth-directed CMEs were observed.

Solar Wind / Geomagnetic Activity: Solar winds, at L1 were observed just above 500km/s by DSCOVR but also measure closer to 600km/s by ACE (currently some uncertainly between the two spacecraft) with a recent trend downwards towards the end of the period and solar winds are probably slight-elevated now below 500 km/s. Density remains mostly below average following the impact of the CME on 17 Dec. The Interplanetary Magnetic Field (IMF), Bt, remained weak, around 5-8nT throughout. The north-south component, Bz, fluctuated between -7nt and +6nT. The phi angle was predominantly negative (towards the Sun). Geomagnetic activity was Quiet to Unsettled (Kp1-3).

Energetic Particles / Solar Radiation: High energy proton flux observed by GOES18 was at background levels. High energy electron flux (greater than 2MeV) observed by GOES16 was background, with a diurnal peak into Moderate levels. The associated 24-hour fluence was below the Active (1e8 integrated flux) threshold. The 19/0000 UTC observation was 5.45e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Low to Moderate Solar activity is forecast with a chance of further isolated M-class flares. These most likely from either AR924 in the southwest or AR3927 in the southeast. The probability increases gradually through the forecast period, due to more active regions anticipated to rotate across the southeast limb from the far-side.

Solar Wind / Geomagnetic Activity: The CME experienced at Earth during the morning of 17 Dec has largely passed, with Quiet to Unsettled (Kp1-3) activity expected. Solar winds, now at slightly elevated levels, around 530 km/s, may reach Slow-ambient levels by Day 3 (21 Dec). Several CMEs

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 370 900 0100 Email: enquiries@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.

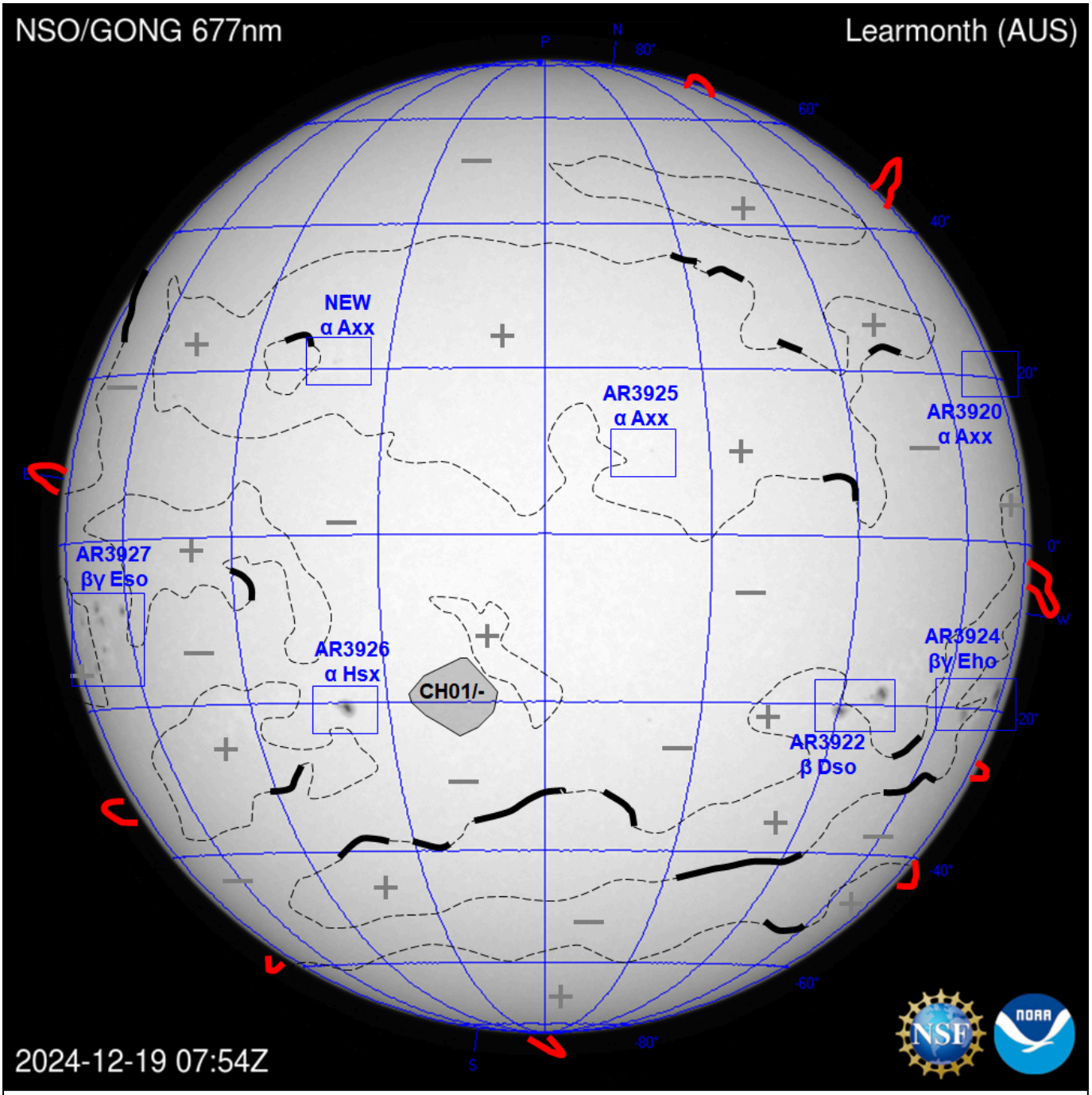
that left the Sun in the past few days are forecast as near misses, but cannot be completely ruled out as flanking arrivals at Earth, so there is some uncertainty in the forecast currently.

Energetic Particles / Solar Radiation: High energy proton flux is expected to remain at background, but carries a slight chance of reaching S1/Minor Storm levels, in response to any notable solar flares. High energy electron flux is likely to reach moderate levels at times with diurnal peaks reaching the high threshold. However, the 24-hour fluence is expected to remain below the Active threshold throughout.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 370 900 0100 Email: enquiries@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.

Figure 1: Solar Synoptic Map valid 19/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 370 900 0100 Email: enquiries@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.

Geomagnetic Storms

Solar winds have now reduced into Slightly Elevated levels. A gradual decline is anticipated to continue by the end of Day 2 (20 Dec) will probably be at Slow-Ambient levels. Geomagnetic activity is at Quiet to Unsettled (Kp1-3) levels. Any previous estimations of CME arrivals are likely to have been swept up and are no longer forecast to have any impact on Earth, although this is perhaps the main source of uncertainty in the forecast.

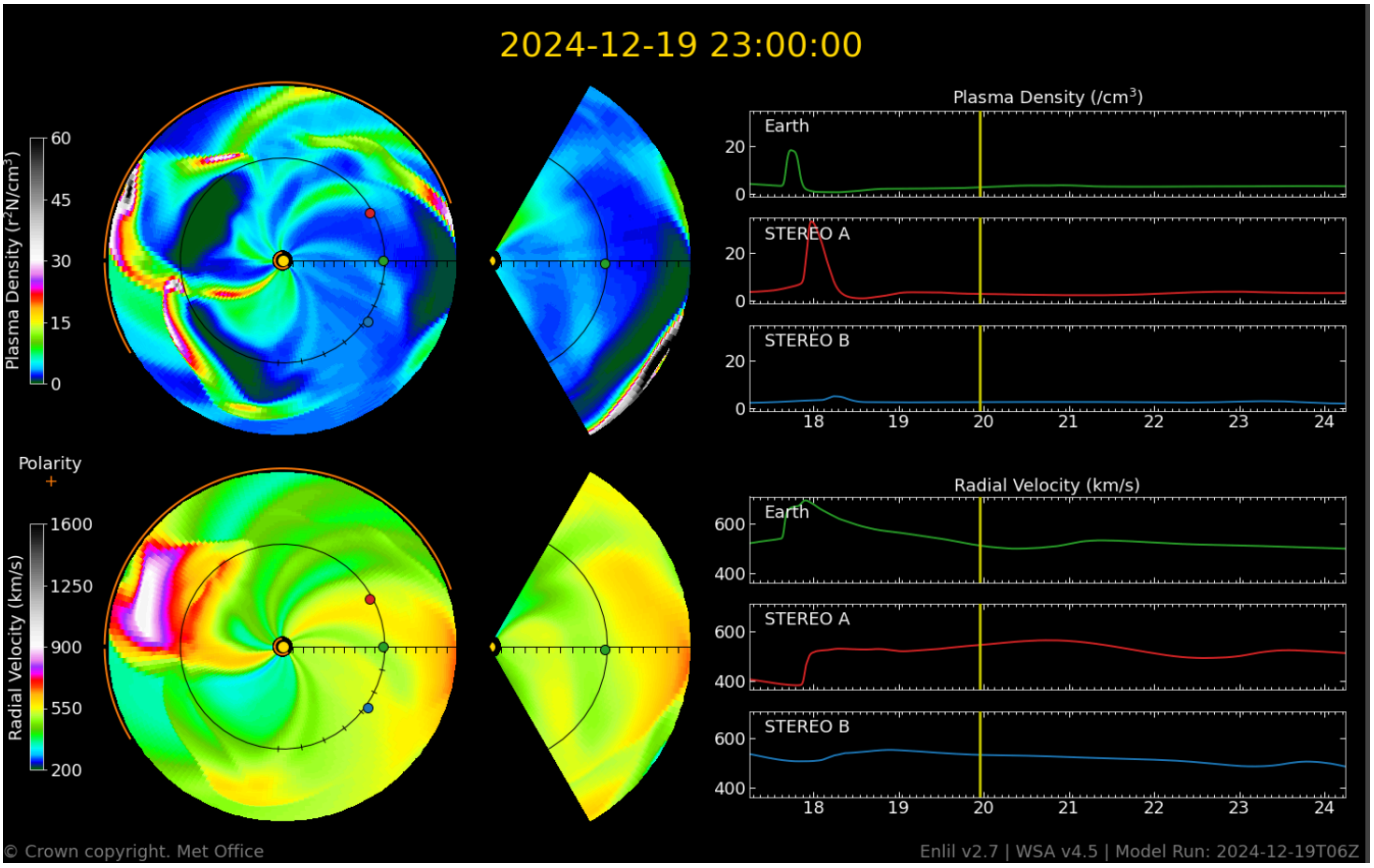
A very fast halo CME was evident in LASCO imagery around 17/1600 UTC, however this appears with good confidence to be far-sided with minimal impact to Earth. There have been no further significant CMEs observed in the Earth-Sun line. A small coronal hole, CH01-, has developed in the eastern hemisphere, this doesn't appear to be a particularly persistent feature and any connection to the HSS from it, is likely to be after the current forecast period and most likely rather weak given it's size and the proximity to the winter solstice. Geomagnetic activity is expected to be Quiet to Unsettled (Kp1-3) throughout, with Active (Kp4) intervals unlikely.

Geomagnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	20	10	5	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 370 900 0100 Email: enquiries@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.

Figure 2: Latest run of the Met Office ENLIL model.



© Crown Copyright 2024. All Rights Reserved.

Radio Blackouts - X-Ray Flares

There are seven sunspot regions on the Earth-facing disc. AR3924 in the southwest, remains the largest and most complex region, consisting of a large, symmetric leading spot and a similarly sized and more irregularly shaped trailing spot, although has shown little development in the last 24 hours. AR3922 is the second largest with a hint of intermediate spots, but has remained similar in size and magnetic complexity in the last 24 hours. The newly numbered AR3927 has made its way further on to the disc and is likely to increase in size and complexity as it comes further into view in the next 24-48 hours, with notable looping in imagery. The remaining regions on the disc are smaller and magnetically simple.

Solar activity is now at Moderate levels once more following the recent M-class flare. The emergence of further sunspot regions expected to rotate onto the disc from over the east limb between Days 1 and 2 (19-20 Dec) increase the chances of M-class flares with time as shown in the table below. These regions perhaps corresponding to Ex-AR3905 and Ex-AR3906. These regions have a history of generating M-class flares when they were last on the Earth-facing side of the solar disc. Recent far-sided CME activity and helio-seismic soundings suggest that at least one of these regions remains active.

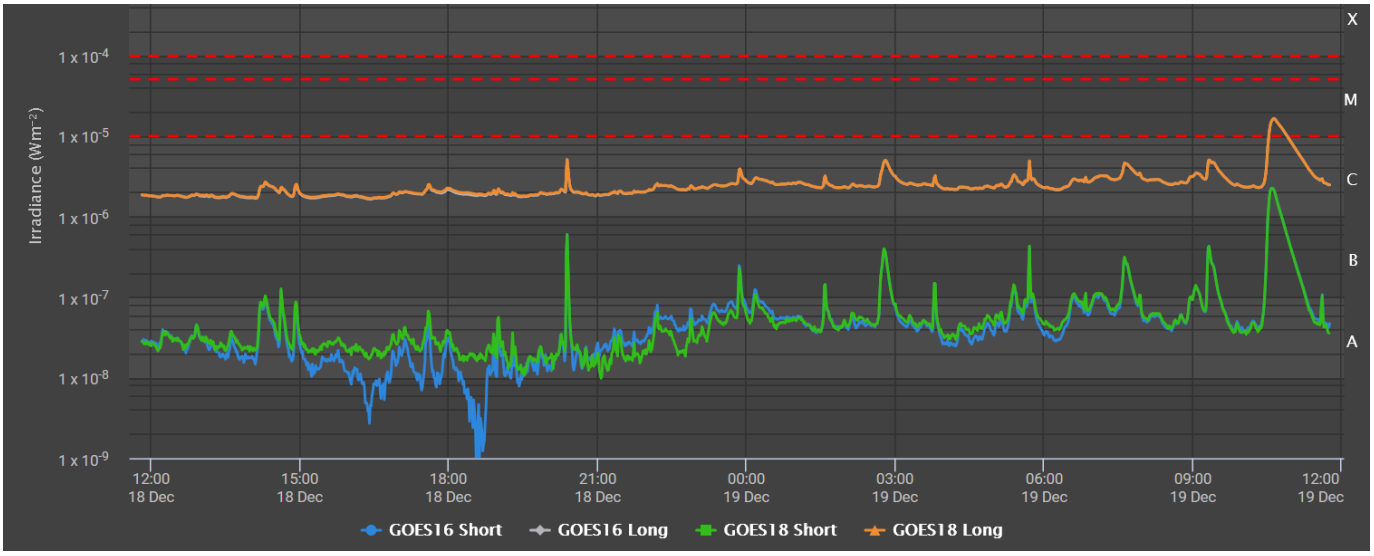
Low to Moderate solar activity with a chance of isolated M-class. The probaility rises to Likely by Day 2 (20 Dec). Slight chance of isolated X-class flares is maintained throughout and this probability may rise too in coming days.

X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 (M Class)	Yes	40	60	60	60
Very Active	R3-R5 (X Class)	No	2	5	5	5

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 370 900 0100 Email: enquiries@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.

Figure 3: Latest plot of the X-ray flux at GEO from GOES with recent M-class flare.



© Crown Copyright 2024. All Rights Reserved.

Solar Radiation Storms (High Energy Protons)

AT GEO the GOES18 proton flux is at background levels. There is a continuing slight chance of reaching S1/Minor Storm levels, in response to any notable solar flares, currently most likely from AR3924 and AR3922. AR3924 will likely rotate over the western horizon on Day 2 (20 Dec), shortly followed by AR3922, but proton storm probabilities are maintained after it leaves the visible disc. In the meantime, other regions look magnetically simple and any other complex groups that may rotate on to the disc will remain the in the eastern hemisphere for the forecast period.

Radiation Storms Probability (Exceedance)	Level ($cm^{-2}sr^{-1}s^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	15	15	15	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 370 900 0100 Email: enquiries@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.

High Energy Electrons (≥ 2MeV)

High energy electron flux observed by GOES16 has been at background levels, diurnally rising to Moderate following the influence of the recent CME arrival on 17 Dec. The CME likely caused the electron belts to become compressed away from GEO. However, as the CME influence wanes the Van Allen belt will continue to relax and expand back towards GEO in coming days. As a result, the electron flux at GEO may peak at high levels within the diurnal cycle.

The associated 24-hour fluence will increase in response but is likely to remain below the Active (1e8 integrated flux) threshold until the end of the period when the threshold may be breached as indicated by the higher probabilies by Day 4 (22 Dec). MOSWOC REFM output is considered to be providing good guidance in this aspect.

GEO Electron Environment	Level ($cm^{-2}sr^{-1}$ day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ 1×10^{8}	No	5	10	30	40
Very Active	≥ 2 MeV ≥ 1×10^{9}	No	1	1	1	5

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 370 900 0100 Email: enquiries@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.

Figure 4: High energy electron flux at GEO from GOES (upper) and Met Office REFM output indicating probable increase in activity.

© Crown Copyright 2024. All Rights Reserved.